REMARKS

Claims 1-3, 5, 6 and 10 stand finally rejected under 35 U.S.C. 103(a) as unpatentable over Isowa (GB 2,308,392) in view of Osgood (U.S. 3,919,029).

Independent claims 1 and 10 were previously amended in response to the Office Action dated April 9, 2003. In a subsequent Office Action, dated December 11, 2003, applicant's arguments in support of amended claims 1 and 10 were rendered moot in view of new grounds of rejection. This new grounds of rejection was eventually overcome by the Declaration establishing prior invention.

This Amendment addresses the obviousness rejection of claims 1-3, 5, 6 and 10 based on the Isowa/Osgood combination, which rejection has now been made final.

This rejection is respectfully traversed in view of the parent amendments to claims 1 and 10 and the comments which follow:

Applicant's prior amendments of claims 1 and 10 were intended to provide a clear distinction between two distinctly different types of single facers, the prior art pressure roll single facers characterized by Isowa and Osgood, and the more recently developed bonding roll single facer characterized by applicant's device. The distinctions between these two types of single facers have been detailed in applicant's specification and in arguments previously made, e.g. on pages 6-8 of applicant's Amendment filed on October 14, 2003, and these arguments are believed to be relevant and sound. In the current Office Action, however, the Examiner points out that the claim limitations as currently recited in claims 1 and 10 do not exclude the pressure roll single facer as disclosed by Isowa. In addition, the Examiner points out that Osgood has been relied on only to show the concept of heating a bonding roll. Also, it is pointed out that Isowa discloses that the Isowa pressure roller system applies less pressure than those of previous systems, suggesting therefore that the force applied by a pressure roll may be considered to be relative.

In the present amendments to claims 1 and 10, applicant's have added additional language to further clarify their invention and to distinguish it from the disclosure of the Isowa/Osgood combination, as well as the other cited prior art.

In both Isowa and in Osgood, the pressure roll construction of the single facer is characterized by a pressure roll nip which is the initial point at which the corrugated

medium web (with glued flute tips) and the liner web are brought into tangent contact. It is at this pressure roll nip that, in Isowa, the "liner 26 is press-pinched to the crest portions of said core paper web 16 between the first pressure roll 34 and the second corrugating roll 14, wherein the initial sticking of the core paper web 16 and liner 26 are carried out". (Page 13, lines 19-22). To confirm that the pressure roll in Isowa exerts a significantly high force, the general alignment of corrugating rolls 12 and 14 and pressure roll 34 is noted with the further comment that "a pressing force of the first pressure roll 34 does not operate in the direction of displacing the second corrugating roll 14 relative to the meshing area between the first corrugating roll 12 and the second corrugating roll 14, the pressing force does not hinder the formation of corrugations of a core paper web at either of the corrugating rolls 12, 14 et al". (Page 13, lines 27-32). As pointed out in prior arguments, Osgood also confirms that a pressure roll single facer relies on high nipping pressure, i.e. 186 pounds per linear inch. Again, this high nipping pressure of the nipping roll pressing the web against the corrugating roll or bonding roll is provided at the initial contact point between the medium web and the liner web. The result of this contact is a primarily mechanical bond and not a true adhesive bond. The result, as pointed out previously, is a squeezing of that portion of the adhesive glue line from the very tip of the flute in contact with the liner. The Examiner's attention is called to the enclosed copy of a section entitled "SINGLE FACE GLUE LINE" in a paper entitled "Analysis of the Glue Lines in Corrugated Board", authored by W.S. Thayer and C.E. Thomas and published in Corrugator Bonding TAPPI PRESS, 1993. In particular, the discussion of the adhesion in region 4 of the glue line formed in a high load pressure roll single facer is discussed. This supports applicants' position that where initial tangent contact between the glued flute tips of the medium web and liner web occurs at a high pressure nip roll, the glue bond is lost in that region.

In applicant's bonding roll single facer, the component webs 11 and 16 are brought into initial tangent contact without any nipping contact at all, in a manner completely contrary to the teaching in pressure roll patents such as Isowa and Osgood. The initial tangent contact in the subject apparatus and in accordance with the corresponding method is provided by the generator roll 15 which is positioned to permit the liner web 16 to wrap gently against the glued flute tips of the corrugated medium web 11. Only after this initial

contact is made does the contact roll 18 press the component webs lightly to spread the adhesive glue lines in a manner that precludes squeezing the glue from the points where the flute tips contact the liner web. The positioning of the contact roll 18 immediately downstream of the generator roll 15 allows the adhesive glue lines to be spread before gelatinization of the starch. As has been pointed out previously, if portions of the glue lines are virtually completely squeezed away from the flute tips by the high nipping force of the pressure roll, a significant portion of the glue line has no glue to gelatinize and a significant portion of the glue line strength is lost.

Claims 1 and 10 as now amended are believed to exclude and distinguish over pressure roll single facers of the types disclosed in Isowa and in Osgood. As a result, the claims are now believed to clearly distinguish over the Isowa/Osgood combination and to be in condition for allowance. Remaining dependent claims 2-9, 11 and 13 are believed to be allowable by virtue of their dependence on an allowable independent claim and in view of arguments previously made.

Reconsideration and allowance of claims 1-11 and 13 is respectfully requested.

Respectfully submitted,

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SINGLEFACE GLUE LINE

The geometry of a typical singleface bond is shown in Figure 7.2. These photomicrographs, taken on a scanning electron microscope, indicate that the singleface glue line is symmetrical about its centerline, and that the bond structure of each half consists of four distinct regions: (1) an exterior region, (2) a fillet region, (3) a high strength region, and (4) a high pressure region. The surrounding photomicrographs show each of these regions in detail.

Region 1 shows the outer edge of the adhesive film on the side of the flute. The starch granules in this area are completely ungelled due to the rapid loss of water, by paper absorption, from the thin boundary film. Since *both* water and heat are required for gelatinization, this loss of water served to inhibit granular gelatinization. Obviously, this region does not contribute in any way to the bond strength of the glue line; thus, the starch solids deposited in this area are wasted.

Region 2 shows the squeezed out adhesive film spanning the gap between the medium and liner surfaces. Except for the boundary area adjacent to region 1, the adhesive in this region is almost completely gelled. This is due to the relatively large quantity (thickness) of liquid adhesive which served to entrap sufficient water to allow the gelatinization process to occur.

AT WHAT POINT IN PROCESS

Region 3 shows the surface of the adhesive film which forms the bond with the liner. The adhesive in this region is completely gelled. It has dried in a characteristic cellular pattern which developed as a portion of the water evaporated from the film of gelled adhesive. These cellular structures span the gap between the medium and liner surfaces. Since the cells are firmly anchored to the paper surfaces, they represent the area of highest bond strength in the singleface glue line.

Region 4 shows the crest of the flute which was exposed to very high pressure in the singlefacer. The granules in this region, like those in the exterior region, are also ungelled. However, they show definite signs of combining to each other and to the paper fibers. The presence of these ungelled granules, as evidenced by the intact helium or botanical center shown in the lower photo, suggests that the water migrated out of this thin adhesive film as a result of the high pressure, before gelatinization temperatures were attained.

Since the granules in the center regions of the glue line were exposed to an extreme pressure, one would, intuitively, expect this pressure to drive the granules deep into the paper. To investigate the nature of adhesive penetration throughout the glue line, a sample of single-face

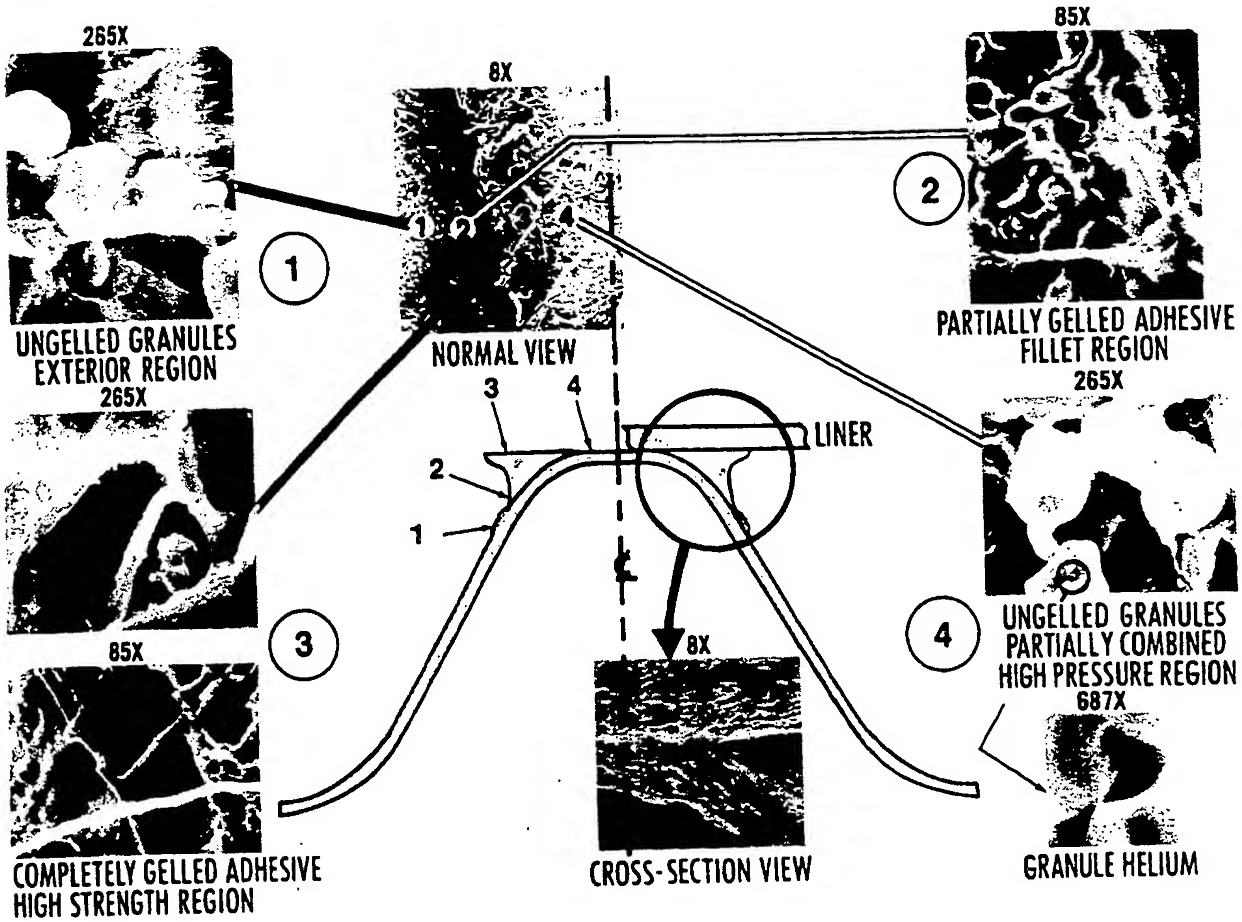

Fig. 7.2. Singleface glue line—four distinct regions.

board was separated dry and mounted on a flat surface. Both medium and liner glue lines were surface ground to incremental depths of 1, 2, 4, and 6 mil. (25, 50, 100 and 150 μm). These ground samples were then iodine stained to expose the adhesive.

Figure 7.3 contains photographs of these medium and liner samples and photomicrographs of the surface at each depth. A comparison of these surfaces indicates that the penetration is quite similar in both the medium and liner. In the unground glue lines, a thick surface of gelled and ungelled starch is present. At the 1 mil. (25 μm) depth, this film of starch adhesive is plainly visible on the fibers of the paper. At the 2 mil. (50 μm) depth, the gelled starch film is still plainly visible; however, very few ungelled granules can be detected. At the 4 mil. (100 μm) depth, several traces of solubilized starch solids are faintly visible, especially in the medium which is less dense. At the 6 mil. (150 μm) depth, there is no apparent penetration in either liner or medium. The preceding results represent the analysis of a typical sample. For other samples, allowance should be made for variations due to paper and adhesive.

So appl is THIS
Good A,

With the characteristic geometries of the singleface glue line defined, the process can now be traced through the conventional singlefacer. The bonding process begins as adhesive is applied to the newly formed flute tip. At this point of application, the paper surface temperature is above the adhesive gel point. As the relatively cool adhesive contacts the flute surface, it wets the paper fibers and heat energy begins to flow into the liquid film. This flow of heat continues as the flute travels from the applicator roll to the pressure roll; however, gelatinization does not occur in this region. If it did, the granules in the center areas of the glue line would be gelled since gelatinization is an irreversible process.

As the flute tip with the adhesive passes thru the pressure nip, the liner is joined under high line pressures, up to 5000 psi. This pressure induces rapid wetting on the liner surface by forcing the liquid adhesive into the spatial areas surrounding the surface fibers. As these areas become filled, the excess fluid squeezes out on both sides of the flute tip leaving a thin film between the two substrates which is barely enough to wet the contact areas.

BAD Low Form
STRENGTH

As the high pressure is released, the compressed spatial regions of the paper expand, and, thus, thin the adhesive film even further. Since the surface area of this thin film is very high, the liquid water rapidly escapes and starves the still uncooked granules in the high pressure region of needed water. The adhesive, which is squeezed out on both

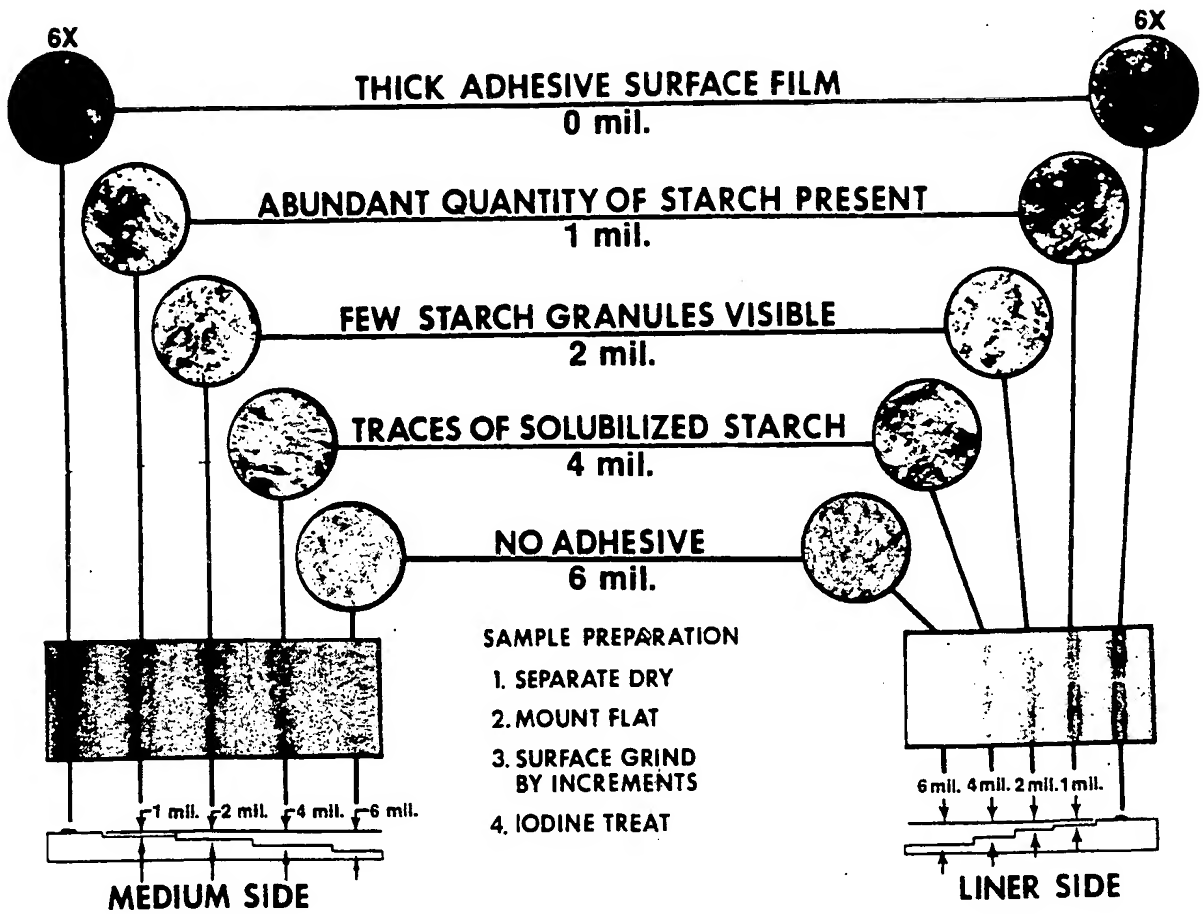

Fig. 7.3. Adhesive penetration—singleface glue line.

sides of the high pressure region, has a sufficient quantity of water entrapped. It then gelatinizes from the residual process heat as it journeys to the bridge and slowly dries in the characteristic cellular pattern while it travels along the bridge.

Since it has been shown that the adhesive gelatinization occurs beyond the pressure nip, the question arises concerning the mechanism that holds the paper together during its journey to the bridge. Originally, it was believed that the process heat and pressure in the singlefacer caused the adhesive to gelatinize at the pressure nip, creating an instantaneous bond. Recent studies of the tack strength of a 20% solids adhesive on gelling indicate that this initially gelled adhesive is far too weak to hold the paper together under the dynamic stresses exerted by the moving web. Some amount of water must be removed from the gelled glue line in order for it to develop enough strength to withstand these imposed stresses. If the adhesive on the flute tips was gelatinized prior to its entry through the pressure nip, the process pressure could effect this required dehydration by mechanically wringing out the excess water. The adhesive film in Region 4 of Figure 7.2, however, indicates that the granules are ungelled at this point.

To further verify this, tests were conducted on the one-inch wide test singlefacer at the Institute of Paper Chemistry, Appleton, Wisconsin. In these tests, the fluted medium, with the applied adhesive, was diverted from the pressure nip into a beaker of liquid nitrogen at -320°F (-196°C). These quick-frozen paper samples were later freeze-dried to remove the water and capture the state of the applied adhesive. Figure 7.4 contains a photomicrograph of this freeze-dried sample and a sketch of the equipment used to prepare it. This photomicrograph, which shows the ungelled granules encased in a solidified film of the cooked starch carrier, verifies that the adhesive film on the flute tip is, in fact, ungelled as it enters the pressure nip.

Although the adhesive was ungelled as it entered the pressure nip, there was evidence of sufficient heat exposure to reduce the angularity of the granular surfaces. This limited heat exposure partially solubilized the outer surfaces and weakened the intermolecular structure of the granules. This weakening caused a portion of amylose solids to migrate toward the outer boundary of the weakened granules and the granular surfaces to become "tacky." As these plasticized granules pass through the pressure nip of the singlefacer, they are instantaneously joined to each other and to the surrounding cellulose fibers. These pressure-induced, but water-starved, granular conglomerates collectively act to

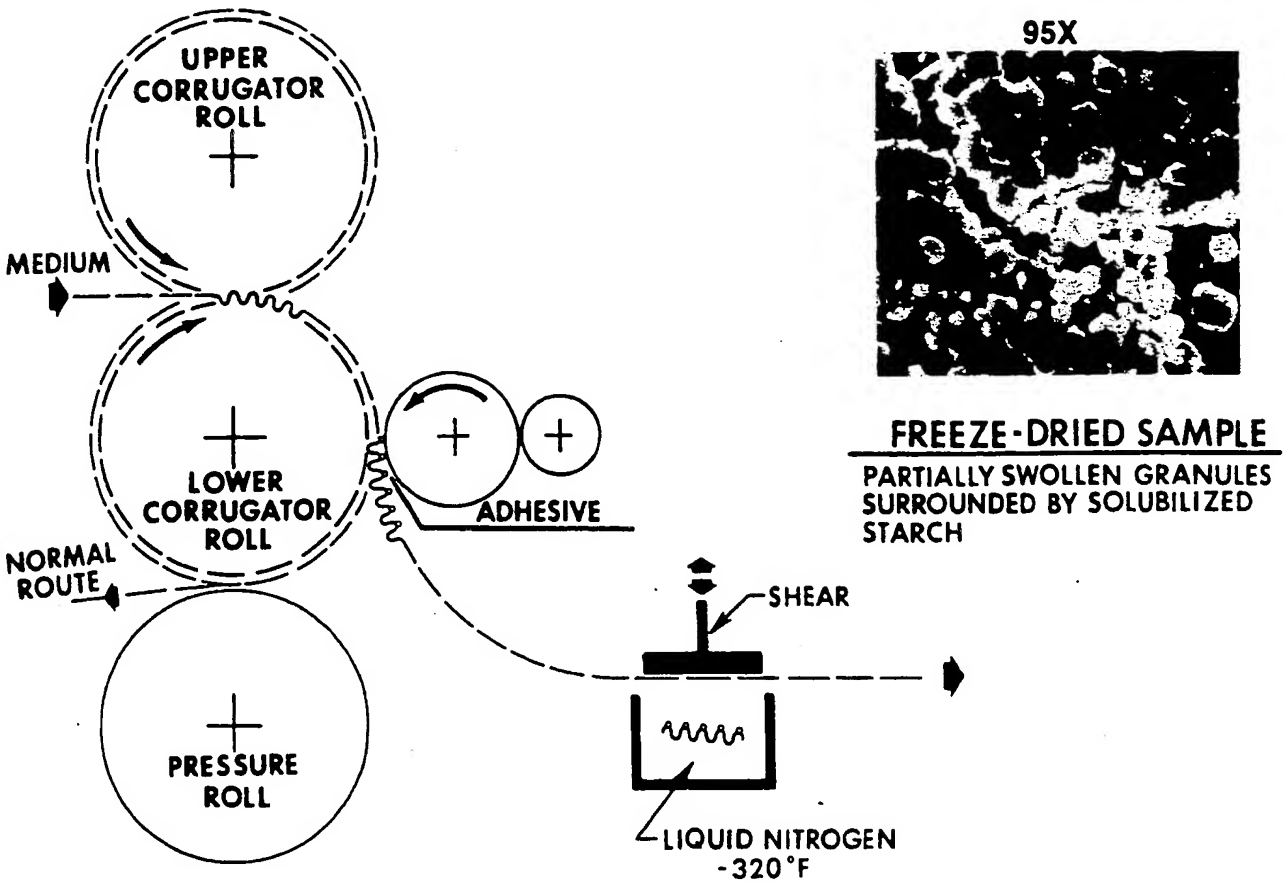

Fig. 7.4. Starch condition upon application to paper.

hold the paper together while the squeezed-out portion of adhesive gelatinizes and dries. This theory is supported by the extreme density of combined granules shown in Region 4 of Figure 7.2, and by the relative absence of this phenomenon in Region 1.

DOUBLEFACE GLUE LINE

The geometry of a typical doubleface bond is shown in the series of photomicrographs in Figure 7.5. The photograph in the lower center of the figure shows the cross section of an undisturbed glue line. Upon examining this photograph, the adhesive film, which extends across the width of the glue line, is approximately 2 mil. (50 μm) thick and appears to have been completely gelled. This film continuity is due to the light process pressure of the doublefacer and is in direct contrast to the singlefacer bond which is devoid of gelled film in the center area.

The photograph in the upper center of Figure 7.5 shows the medium side of the glue line which has been separated and viewed normal to the board surface. Upon examining this photograph, three geometric regions can be observed: (1) an exterior region, (2) a fillet region, and (3) a high strength region.

Regions 1 and 2 show the adhesive film on the side of the flute and in the fillet region, respectively. These regions are identical to the corresponding regions of the singleface glue line.

Region 3 shows the surface of the adhesive film which contacted the liner. Since the adhesive was not squeezed out of the center areas, the resultant film of liquid adhesive was thick enough to entrap a sufficient quantity of water for gelatinization. Therefore, the film is completely gelled, and it spans the entire width of the glue line. In the areas near the side of the flute, where the span between the medium and liner becomes large, cellular formations can be observed. These formations occurred as the material content of the liquid adhesive was reduced on drying. Since the adhesive film in these photographs is continuous across the glue line, the total contact area on the paper surface is greater than in the singleface bond. This explains why the pin adhesion values are normally higher on the doubleface side of corrugated board.

The formation of a doubleface glue line begins as the singleface web flows from the bridge, over a 36-in. (914 mm) preheating roll, and into the glue unit where adhesive is applied to the flute tip. As a result of preheating, the surface temperature of the flute tip, at the point of adhesive application, varies from 140°F to 190°F (60–88°C) depending